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(54) Title: DECONTAMINATION OF PIPEWORK

(57) **Abstract:** The invention provides a method for the decontamination of the interior of a fluid flow channel, or the descaling of a trace active plate heat exchanger, used in the processing of radioactive materials, wherein a fluid, mass or agglomerate, consisting essentially of solid particles cohering by means of a wetting liquid, is caused to pass along the channel in contact with its interior surface. A particularly preferred mixture comprises a mass of comminuted ice, which is sufficiently flowable, plastic and divisible to pass readily through channels of many different shapes and sizes, to flow past internal obstructions, and to negotiate the branching or merging of channels. Its also has the significant advantages of low cost, and ease and safety of preparation.

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DECONTAMINATION OF PIPEWORK

The present invention concerns a method for the decontamination of pipework and the descaling of heat exchangers in the nuclear industry. Specifically, the method provides a cheap and efficient means of achieving decontamination and descaling whilst avoiding many of the difficulties associated with prior art technology. In addition, the technique allows for the ready clearance of partial blockages which commonly occur in convoluted pipework.

The technique of "pigging" is well known, particularly in the fields of oil and gas recovery and distribution. The technique involves driving a solid body or device shaped to fit a pipeline interior – known as a "pig" – along the pipe under pressure. The pig may have scrapers or brushes to shift contaminants from the interior surface of the pipeline – as, for example, disclosed in US-A-5457841 and US-A-5903945 – or it may be adapted to absorb or otherwise take up debris in the pipeline, in the manner described in US-A-4216026. Alternatively, the pig may be constructed wholly or partly from an elastically deformable material which is able to pass bends and other irregularities in the pipework without damage, whilst maintaining firm contact with the surface of the pipe, and such a device is discussed in US-A-4389461 and US-A-5924158. Another adaptation of the technique – disclosed in US-A-4898197 and US-A-4724007 – proposes the use of a solid bullet of ice as a pig, on the basis that this will disintegrate spontaneously and harmlessly if it becomes lodged in the pipes. The use of a self-sustaining gelled mass, made by gelling a hydrocarbon, is yet another alternative that has been considered.

It is also known, from US-A-4860821, that pigs may be employed in the cleaning of heat exchanger tubes which suffer from the accumulation of internal residues from manufacture or during use.

More conventionally, however, the majority of piping systems are cleaned by direct methods such as brushing and/or flushing with cleaning liquids, since these are much

easier to control than pigs, and also far cheaper. Furthermore, pigs suffer from several other drawbacks associated with their physical nature, which naturally prevents their use in situations wherein pipes having substantially varying cross-section, or including internal obstructions, require cleaning. In such situations, it is necessary to employ liquids for cleaning the pipework.

The present invention seeks to provide means by which the limitations associated with the pigs of the prior art may be overcome. Thus, the invention seeks to provide pigging means which may be employed in the cleaning or decontamination of pipes or other channels having substantially varying cross-section, or including internal obstructions, valves and the like, said pigging means also showing considerable economic advantages over the known devices of the prior art. The invention also seeks to provide an efficient means for the clearance of partial blockages within such pipework. Specifically, the invention is directed towards the cleaning, decontamination and unblocking of fluid channels, heat exchangers and the like which are employed in the nuclear industry and used in the processing of radioactive materials.

Thus, according to the present invention there is provided a method for the decontamination of the interior of a fluid flow channel used in the processing of radioactive materials, wherein a fluid, mass or agglomerate, consisting essentially of solid particles cohering by means of a wetting liquid, is caused to pass along the channel in contact with its interior surface.

The decontamination process is envisaged as including the removal of solid material or deposits from the fluid flow channel which may otherwise result in the partial blockage thereof.

In the present context, a fluid flow channel may comprise any conduit, pipe or other vessel of reasonably small cross section used in the transport of radioactive materials. Furthermore, the invention is also applicable to the descaling of trace active plate

heat exchangers. Hence, the invention also provides a method for the descaling of a trace active plate heat exchanger used in the processing of radioactive materials, wherein a fluid, mass or agglomerate, consisting essentially of solid particles cohering by means of a wetting liquid, is caused to pass through the heat exchanger in contact with its interior surface. In addition, the method of the invention finds particular application for the cleaning of pipework used to deliver cement grout, such as is typically found in radioactive waste encapsulation plants.

Preferred wetting liquids in the context of the present invention are aqueous wetting liquids, and it is desired that the wetting liquid should wet the interior surface of the channel or of the heat exchanger so that the solid particles are able to slide over the surface.

A preferred mode of implementing the method of the invention is by the use of a fluid, mass or agglomerate of a mixture of solid particles with a wetting liquid which is, consists essentially of, or comprises a melt liquid derived from the solid of the solid particles. Such a mixture may, for example, be conveniently prepared by comminuting the solid and using it at a temperature near its melting point.

A particularly preferred mixture in this context comprises a mass of comminuted ice. Such a mixture – or ice pig – shows many advantages over the teachings of the prior art. Thus, it is found to be sufficiently flowable, plastic and divisible to pass readily through channels of many different shapes and sizes, to flow past internal obstructions and through valves, and to negotiate the branching or merging of channels. Specifically, it is found that an ice pig is capable of passing through an orifice plate having a flow area which is 10% of the flow area of a connected channel, then reforming to its original conformation immediately after negotiating the orifice, whereas a conventional pig can typically only negotiate a 35% reduction in area. It is also sufficiently coherent, by virtue of its own meltwater, that it does not disintegrate or disperse in the channel. However, in the event that an ice pig should become lodged in a channel, it will obviously not lead to a permanent obstruction in

the system, since it will eventually melt and flow away. Additionally, of course, ice has the significant advantages of low cost, and ease and safety of preparation.

Ice pigs are found to be especially valuable for use in the nuclear industry where the apparatus to be decontaminated or descaled is in contact with radioactive materials, and an efficient cleaning effect is particularly important. The fact that the process generates minimal secondary waste is of major significance. Furthermore, the ability of the method of the invention to facilitate thorough cleaning of all parts of the channels is especially advantageous and allows for the cleaning process to be carried out at much lower cost, and with greater efficiency, than the known cleaning methods of the prior art. This ability of an ice-pig to mould itself to any topology is seen to be of especial benefit in the case of heat exchangers wherein, in the nuclear industry, hot spent fuel flows down between alternate plates, and cold fluid flows up between adjacent, alternate plates. However, the degree of clearance between plates is small, and often uneven, but the use of an ice-pig allows for the efficient descaling of such apparatus to be successfully achieved.

It will be appreciated that the best results are obtained with the method of the present invention when the process is carried out with a mixture of water and ice, since it is clear that a solid block of ice would suffer from the same problems which are associated with the conventional pigs of the prior art. It is preferred, therefore, that a freezing point depressant should be included in the water used to make the ice. This increases the range of temperature over which coexistent water and ice can persist. Typical compounds which are of use in this context include salt and sugar.

It is also possible to envisage the use of a mass of frozen particles wetted by the melt liquid which comprise other than ordinary ice; thus, for example, a mixture comprising a frozen organic solvent may also be used.

The use of an ice pig in combination with certain chemical decontaminants is also envisaged within the scope of the present invention. As particular examples of

materials which are found to be useful in this context may be mentioned solutions of nitric acid, ethylenediaminetetraacetic acid (EDTA) and citric acid.

The ease of use of the method of the invention is further enhanced by the fact that factors such as particle size and solid:liquid ratio are not critical to its success. The only criteria which have to be met in relation to these parameters are that the largest particle in the agglomerate should be capable of fully passing through the system, and that the mass is sufficiently coherent to move as a body through the system.

The speed at which the mass is driven through the system is also not limited, other than by the parameters of the system under consideration. As an example of potential values which may be appropriate, the range from 0.05 to 5.0 m/s might be quoted.

Typically, the method involves the use of a dense slurry of ice particles, of typical average diameter 1.0 mm, which is forced by pressure down a fluid flow channel and is thereby able to act as a perfect piston, since it is capable of conforming exactly to any variations in channel cross-section or configuration, thereby allowing for the formation of a perfect seal against the walls of the channel. The potential use of the technique for the removal of partial blockages within fluid flow channels thus becomes apparent.

Particular examples of the use of the method of the invention include instances wherein debris may be attached in significant quantities to the walls of a fluid flow channel, or may be coalesced together within the channel, in either case to result in a partial blockage of the channel. In such cases it may not be practically possible to remove the material by simple physical means such as the use of rods in view of the geometry of the system. Additionally, the use of particular chemical means may be significantly disadvantageous – or even impossible – in view of regulatory requirements for waste disposal; specifically, this may apply in the case of, for example, a dip leg of a tank used for the storage of highly active waste.

The latter situation highlights the unique challenges faced within the nuclear industry, wherein the cleaning and decontamination of fluid flow channels involves not only the general considerations associated with the removal of contaminants in the regular process industries, but also the complications introduced by the presence of radiation. Thus, for example, it is desirable – and often necessary – that the volume of cleaning fluid should be kept to a minimum, so as not to generate additional waste, since the costs associated with the disposal of such material escalate rapidly with volume. The specific use, in particular, of ice does, however, provide clear advantages in this regard, since the cleaning material is, in itself, non-toxic and harmless.

The method of the invention also allows for the delivery of the fluid, mass or agglomerate, consisting essentially of solid particles cohering by means of a wetting liquid – the preferred example being an ice pig – at a point some distance from the site of a blockage. This offers significant advantages, since the alternative may involve intervention by breaking into a channel close to the blockage site, which could be both costly and hazardous.

The general costs benefits and ease of use associated with the method of the invention allow for the regular maintenance of systems that might otherwise suffer from a degree of neglect. Again, this is of particular importance in the nuclear industry where the maintenance of low levels of radioactivity is a paramount consideration for reasons of safety. The risks of blockages occurring in these systems is consequently reduced as a result of the high standards of cleanliness that are applied. Thus, the use of this simple and highly efficient technique ensures that plant throughput is maximised since the downtime which could otherwise result from both planned and unplanned outages is greatly reduced.

As specific examples of the use of the technique of ice pigging in the nuclear industry may be mentioned the following:

1) The general cleaning and decontamination of pipework used in the reprocessing of spent nuclear fuel.

2) The removal of partial blockages of solid particles which occur in convoluted pipework during reprocessing, including:

   (a) The removal of cement grout from pipework in encapsulation plants after the grout has been fed into drums of industrial liquid waste (the grout being radiochemically inactive, but being added to active waste and used in an active plant); and

   (b) The removal of deposits following the feeding of highly concentrated radioactive liquor – which has an amorphous solids content and is also prone to crystallisation – to a vitrefication plant.

3) The descaling of pipework in trace active heat exchangers used in the processing of radioactive materials, and particularly of pond water used for the cooling and storage of spent nuclear fuel.

CLAIMS

1. A method for the decontamination of the interior of a fluid flow channel used in the processing of radioactive materials, wherein a fluid, mass or agglomerate, consisting essentially of solid particles cohering by means of a wetting liquid, is caused to pass along the channel in contact with its interior surface.

2. A method as claimed in claim 1 wherein the particles and wetting liquid are aqueous.

3. A method as claimed in claim 2 wherein the particles are ice particles.

4. A method as claimed in any of claims 1 to 3 wherein the wetting liquid is, consists essentially of, or comprises a melt liquid derived from the solid of the solid particles.

5. A method as claimed in any preceding claim wherein the wetting agent contains a freezing point depressant.

6. A method as claimed in claim 5 wherein said freezing point depressant comprises salt or sugar.

7. A method as claimed in any preceding claim wherein the particles comprise a frozen organic solvent.

8. A method as claimed in any preceding claim wherein the fluid, mass or agglomerate is driven through the system at a speed in the range from 0.05 to 5.0 m/s.

9. A method as claimed in claim 3 wherein the ice particles have an average diameter of 1.0 mm.

10. A method as claimed in any preceding claim wherein the fluid, mass or agglomerate additionally comprises a chemical decontaminant.

11. A method as claimed in claim 10 wherein the chemical decontaminant comprises nitric acid, ethylenediaminetetraacetic acid or citric acid.

12. A method as claimed in any preceding claim which comprises the cleaning and decontamination of pipework used in the reprocessing of spent nuclear fuel.

13. A method as claimed in any preceding claim which comprises the removal of partial blockages of solid particles which occur in convoluted pipework during reprocessing

14. A method as claimed in claim 13 which comprises the removal of cement grout from pipework in encapsulation plants after feeding of the grout into drums of industrial liquid waste

15. A method as claimed in claim 13 which comprises the removal of deposits following the feeding of highly concentrated radioactive liquor to a vitrefication plant.

16. A method as claimed in any preceding claim which comprises the descaling of a trace active plate heat exchanger used in the processing of radioactive material.

17. A method as claimed in claim 16 wherein the radioactive material comprises cooling water used in a pond for the storage of spent nuclear fuel.

INTERNATIONAL SEARCH REPORT

International Application No
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A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 B08B9/055 G21C17/017

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 B08B G21C F28G F16L E03F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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Y	US 5 433 236 A (ZOLLINGER ET AL) 18 July 1995 (1995-07-18) abstract column 1, line 19 - line 25 column 6, line 6 - line 12; figure 1 ---	1-8,10, 12,13
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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

° Special categories of cited documents :

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Date of the actual completion of the international search	Date of mailing of the international search report
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C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

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